U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Research on Nuclear Power Plant Retired Components

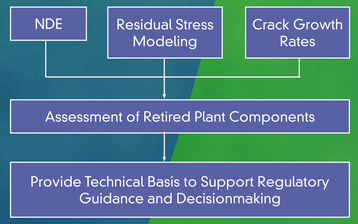
Office of Nuclear Regulatory Research

Introduction

- The NRC is conducting research on metallurgical, weld fabrication, and environmental factors affecting environmentally assisted cracking (EAC).
- Analysis of retired components provides verification and confirmation of laboratory testing and modeling results.

Objectives

- Use retired plant components to evaluate crack growth rates, weld residual stresses, and non destructive examination (NDE) methods.
- Use updated information for component integrity assessment to ensure continued safe operation.



Schematic describing the use of retired plant components

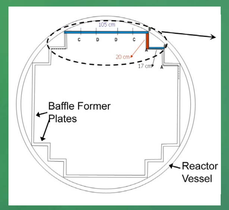
NRC Research

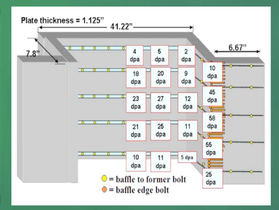
Reactor	Component	Research
Zorita	Reactor core internals	Irradiation-assisted stress corrosion cracking (IASCC)
Davis-Besse	Control rod drive mechanism (CRDM) nozzle	Primary water stress corrosion cracking (PWSCC)
V.C. Summer	Hot leg	PWSCC
North Anna	CRDM nozzle	NDE
St. Lucie	Pressurizer nozzles	Residual stress

Zorita Reactor Internals Materials Research Program

- José Cabrera nuclear power plant (Zorita NPP) was shutdown on 30 April 2006.
- Retired Zorita NPP components were offered to the Spanish Strategic Committee on Nuclear R&D.
- The International Advisory Committee on Irradiation Assisted Stress Corrosion Cracking convened a cooperative research project.

José Cabrera Nuclear Power Station





Schematic of Zorita reactor cross section and radiation doses of the baffle plates and bolts

Use of Results

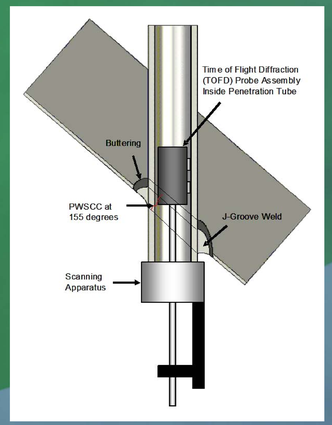
- Currently available data on irradiated stainless steels is typically limited to radiation doses of less than 10 displacements per atom (dpa).
- Reactor internal materials from the Zorita NPP have doses up to 58 dpa which would provide information on the behavior of US LWR components for extended license periods.
- Crack growth rate testing of these materials will provide information which will aid in evaluations of the structural integrity of internals and contribute to establishing inspection frequency guidance.

Assessment of NDE Methods

- The effectiveness and reliability of NDE techniques for inspecting control rod drive mechanism (CRDM) nozzles and J-groove welds are assessed by examining retired components as follows:
  - Perform NDE detection, discrimination, and sizing of component flaws.
  - Evaluate factors that affect the performance of NDE techniques.
  - Compare NDE characterization to actual degradation as determined through destructive analysis.

Use of Results

- Comparison of multiple NDE methods for detecting fabrication defects and PWSCC yielded the following results:
  - Stress corrosion cracks can be tight and difficult to detect using visual and penetrant testing.
  - Ultrasonic testing detected fabrication flaws but was not able to detect the through-weld cracks.
  - Eddy current testing was the most useful technique for finding PWSCC on the J-groove weld.
- The knowledge base of PWSCC is enhanced through nondestructive and destructive characterization of the CRDM assemblies.



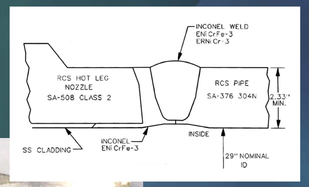
Schematic of North Anna CRDM nozzle with PWSCC cracks and inspection tool

Primary Waterside Stress Corrosion Cracking Tests

- Material from retired components showing susceptibility to PWSCC was obtained from the Davis–Besse and V.C. Summer NPPs.
- Objective is to compare crack growth rate tests on the retired components to laboratory data obtained from surrogate materials.

Use of Results

- Crack growth rates used to develop in-service inspection requirements.
- PWSCC data from retired components allows both alloy and mitigation method development based on service experience.



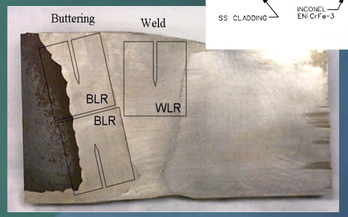
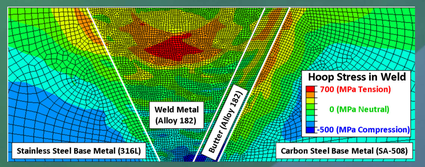
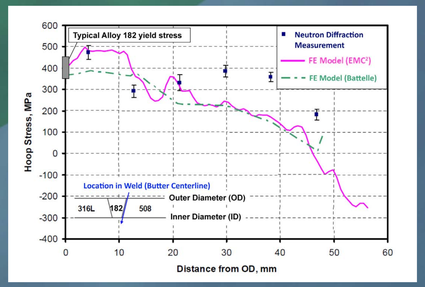


Diagram of the V.C Summer hot leg nozzle-to-pipe weld in the reactor coolant system and crack growth rate specimen locations



Finite Element (FE) model of residual hoop stresses in a weld



Comparison of FE model to measured residual hoop stress ina laboratory specimen

Weld Residual Stress (WRS) Program

- Tensile residual stresses drive PWSCC crack growth.
- Component integrity analyses for PWSCC in DMWs showed that the results were highly dependent upon WRS profiles.
- Memorandum of understanding addendum between the NRC and the Energy Power Research Institute allows cooperative development of WRS program.
- Phase I–IV Program: Sequential WRS model development and validation against experimental WRS measurements.
  - Phase I: simple plates and cylinders.
  - Phase II: international round robin with approximately 20 participants modeling a well controlled lab-fabricated pressurizer surge nozzle.
  - Phase III: relief/spray nozzles from cancelled plant.
  - Phase IV: optimized weld overlay cold leg mockup from cancelled plant.
  - Additional Phase: spray/relief/surge nozzles from retired St. Lucie pressurizer.

Use of Results

- Develop reasonable assurance that WRS model results are justified and validated for use in PWSCC flaw evaluations.
- Refine and standardize modeling procedures for WRS modeling.
- Perform blind validation of WRS models using mockups and retired components focusing on through-wall axial and hoop stresses.
- Develop distributions of WRS profiles from numerous models.
- Determine WRS model accuracy and uncertainties from the distributions obtained from the international results.

Knowledge for Today and Tomorrow